Outline of Phosphoric Acid Fuel Cell (PAFC) Package by Fuji Electric

13th December 2017

Fuji Electric Co., Ltd.
"Fuji Electric Co., Ltd." was established as a capital and technology alliance between Japan "Furukawa Electric Co., Ltd." and German "Siemens AG" in 1923.

The company name derived from these two companies' first sound "Fu" and "Si" and the highest mountain in Japan, Mt. Fuji.
Fuji Electric’s business

Power Electronics Systems
- Factory energy management systems (FEMS)
- Uninterruptible power systems
- Substation equipment
- Magnetic switches
- General-purpose inverters
- Gas analyzers
- Industrial drive systems
- Passenger door systems

Power and New Energy
- Steam turbines
- Geothermal power generation
- Fuel cells

Electronics Devices
- IGBT modules
- SiC modules
- Power MOSFETs

Food and Beverage Distribution
- Can and PET bottle vending machines
- Vending machines for food and other goods (models for China and other Asian markets)
- Freezers and refrigerated showcases
# Development of PAFC at Fuji Electric

<table>
<thead>
<tr>
<th>Year</th>
<th>Field tests</th>
<th>Commercialization</th>
<th>Business expansion</th>
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<tr>
<td>1973</td>
<td>✡ Development of fuel-cell stacks</td>
<td>✡ Achievement of long lifetime (40,000h)</td>
<td>✡ Shipment of &quot;FP-100i&quot;</td>
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<tr>
<td>1998</td>
<td>✡ All-in-one packaging Operable in cold climates [-20 to +40 deg. C]</td>
<td>✡ Extension of lifetime (60,000h)</td>
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<td>2010</td>
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*Development of PAFC at Fuji Electric*

- 1973-1990: Field tests
- 1998: Commercialization
- 2010: Business expansion

**Achievements:**
- Development of fuel-cell stacks
- Achievement of long lifetime (40,000h)
- Extension of lifetime (60,000h)

**Shipments:**
- "FP-100i"

**Focused on 100kW PAFC fuel cells:**

- Because of prospects for a large market and for cost reduction by mass-production.

**Field tests over 90 sites**

- 50kW
- 100kW
- 500kW
- 5000kW

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Installed Fuel Cell Packages

- Germany: 8 units (one is before site test)
- Korea: 6 units
- USA: 2 units
- Japan: 67 units
- France: 1 unit (Before site test)
- South Africa: 1 unit

As of December 2017
## Major Specifications of FP-100i

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
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<tr>
<td><strong>FC Type</strong></td>
<td>PAFC / Phosphoric Acid Fuel Cell</td>
</tr>
<tr>
<td><strong>Rated output power</strong></td>
<td>AC 105 kW [at generating point]</td>
</tr>
<tr>
<td><strong>Output voltage</strong></td>
<td>AC 400V, 3-phase and 3-wire</td>
</tr>
<tr>
<td><strong>Output frequency</strong></td>
<td>50 Hz</td>
</tr>
<tr>
<td><strong>Electrical efficiency</strong></td>
<td>42 % [LHV] [at generating point]</td>
</tr>
</tbody>
</table>
| **Thermal output and efficiency** | High temperature recovery at 105kW operation: 45 kW (90°C)  
Low temperature recovery at 105kW operation: 78 kW (45°C)  
Total efficiency: 91% when all recovered heat is used |
| **Exhaust gas**                   | NOx: less than 5 ppm [O₂ 0 %]  
SOx, dust: less than the detection limit |
| **Consumption of gas**            | Natural gas: 26 m³N/hour |
| **Operating system**              | Fully automated / Grid-connected and Standby |
| **Dimensions**                    | 2.2m (W) x 5.9m (L) x 3.5m (H) |
| **Weight**                        | 14.5 ton |
Features of fuel cell

1. **Distributed power source**
   “100kW” is optimal capacity to small and medium-sized building.

2. **Combined heat and electricity**
   FC generates both electricity and heat.

3. **Environmentally friendly power source**
   FC has low emissions of toxic substances, a low noise level and no vibration as well.

4. **High efficiency**
   Total efficiency including electricity and heat reaches more than 90%.

5. **Fuel flexible**
   FC has flexibility in applicable fuel including natural gas and biogas.

6. **Application of “low-oxygen exhaust air”**
   Low-oxygen exhaust air from FC is applicable to preventive fire protection in facilities.
Environmentally friendly power source

Features of Phosphoric Acid Fuel Cell

- **NOx emissions**
  - Diesel engine: 1400 ppm
  - Gas turbine: 40 ppm
  - Gas engine: 100 ppm
  - Fuel cell: 5 ppm

- **SOx emissions**
  - Diesel engine: 250 ppm
  - Gas turbine: 0 ppm
  - Gas engine: 0 ppm
  - Fuel cell: 0 ppm

- **Noise**
  - Diesel engine: 100~110 dB
  - Gas turbine: 110 dB
  - Gas engine: 90~100 dB
  - Fuel cell: 60~65 dB

- ✔**Exhaust gas is clean.**
- ✔**Noise level is low.**
Configuration of FP-100i package

- Nitrogen gas vent
- Make-up water
- Cooling water (Outlet)
- Cooling water (Inlet)
- Waste water
- Waste-heat treatment equipment
- Exhaust gas outlet
- Inverter/Controller
- Fuel-cell stack
- Reformer
- Water-treatment equipment
- Nitrogen gas cylinders
- Fuel-cell stack
- Desulfurizer/Shift converter

Dimensions:
- 3.5m
- 2.2m
- 5.9m
Our PAFC packages are capable of performing functions conventional power plants cannot perform.
Fuel-cell package application

Energy source
- Hydrocarbon
  - Gas field (Natural gas)
  - Oil well (LP gas)
  - Sewage treatment plant (Digester gas)
  - Biomass plant (Biogas)
  - Chemical factory (By-product gas)

Fuel-cell package
- Hydrogen
- Reformer
- Fuel-cell stack
- Electricity
- Heat
- Air with a low concentration of oxygen

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Highly efficient power generation with hydrogen

- Electrical efficiency is high: 48%.
- Steelworks supplies hydrogen gas through a pipeline.
- The first package began to operate in 2011.

This fuel-cell package was installed by the Research Association for Hydrogen Supply/Use Technology (HySUT) as a part of proof-of-concept tests funded by the Ministry of Economy, Trade and Industry (METI).
Pure hydrogen gas-fed fuel-cell systems

Natural gas-fed system

System for recycling hydrogen gas

Pure hydrogen gas-fed system
Application of Fire-prevention

Fire-prevention of a tire warehouse with our 100kW fuel cell system.
Application of Fire-prevention

Fire prevention of a 30,000 m³ deep freezing warehouse with our 100kW fuel cell system.
Hypoxic air technology for fire prevention

Hypoxic air technology for fire prevention, also known as oxygen reduction system, is an active fire protection technique based on a permanent reduction of the oxygen concentration in the protected rooms. Unlike traditional fire suppression systems that usually extinguish fire after it is detected, hypoxic air is able to prevent fire.

**Usual condition**

Oxygen concentration 21%

**Fire prevention**

Low oxygen air (11~14%)

Oxygen concentration 17%

Fire cannot start!
Required O2 concentration for Fire-prevention

Food: Ignition limit is 17% of oxygen concentration
Fire prevention system will be built by cooperation with MINIMAX.
Conventional fire prevention and extinguishing systems never show a ROI.
We will create larger markets by providing customers with additional value;
We will increase our production capacity to satisfy the increasing demand for fuel-cell packages;
You can also find all the information about our products in our brochures. Or simply get in touch with us. We would be happy to answer your questions about our fuel cell technology or specific projects. Give us a call, or write to us.

+49 3841 75845-00
info@N2telligence.com

Fuji N₂telligence GmbH
Königstraße 30
22767 Hamburg

Office Wismar
Alter Holzhafen 15
23966 Wismar